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Losses from Defect in Piedmont Hardwoods

by

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INTRODUCTION

During the past several decades, a large acreage of hardwoods has accumulated in the Piedmont on which most of the trees are either defective or regarded as undesirable. The older and larger of these trees are of poor quality because of uncontrolled fires, "high grading," careless logging, overgrazing, and a general lack of management. More recently, better fire control and changes in farmland use have increased the number of young unmanaged stands, adding further to the total volume of low-value hardwoods. Insects, diseases, and mechanical injuries are further factors contributing to the general decline in quality.

The need for research on hardwood quality has been intensified by the recent finding that the total volume of hardwoods in the Piedmont is increasing and now exceeds that of pine, and also by the increasing demand for hardwood products. Because of short supply, many of the small Piedmont hardwoods are being harvested now, and utilization is close. It is essential, therefore, to distinguish between defective or diseased and good-quality sound trees (Forest Service Hardwood Log Grades provide the best present measure of factory lumber quality), to find ways to use and profitably harvest the present defective trees for products other than lumber, and to learn how to obtain better quality in the crops of the future. Accomplishing these aims requires a knowledge of the prevalent defects of hardwoods in the Piedmont, and how they can be recognized in the various species. As a first step in obtaining the desired information, a woods survey and mill study were started in 1955. A preliminary report on part of the woods survey data was issued in 1958 as Southeastern Station Research Note 115, "Defect in Piedmont Hardwoods" (1).

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LITERATURE REVIEW

Many investigators have written of the poor condition of the hardwood component of forests in the South. Jemison (15) mentions "the defective low quality hardwood stands so prevalent today." Wahlenberg (24) listed as one of the two main causes of the lowered value of hardwood forests "... the policy of removing trees of the best species and quality first, continued without abatement to the present day." As a consequence, Harrar (8) recently wrote of hardwoods, "In general, log quality throughout the entire southeastern region is in steady decline. Virgin timber has been virtually depleted in many sections, and smaller, more highly defective, second-growth timber is being processed in ever increasing quantities." He further declares that "... rare indeed is the relatively small, second-growth tree-length log that does not exhibit one or more indicators of defect at some level along its bole."

A recently completed timber survey in central and northern Georgia revealed that 41 percent of the hardwood volume is unmerchantable because of cull (17).

Hepting (10, 11) has studied and reported the effects of fire scars and their relation to butt rot and extent of cull, both in southern hardwoods and Appalachian oaks. The progress of heart rot following fire in bottomland red oaks has been described by Toole and Furnival (23). Hepting et al. (13) studied the relation of external features to top rot in Appalachian oaks. Roth and Sleeth (20) reported the incidence of butt rot in unburned sprout oaks and suggested control measures.

Although fire protection and more careful logging have reduced losses from butt rot and other diseases in some stands the effects of diseases are still of major consideration in defect studies. "Timber Resources for America's Future" (12) states that diseases account for 45 percent of the growth impact [2] caused by all destructive agents, and that heart rot and other stem diseases are the most important single group, causing 80 percent of the growth impact due to diseases.

The importance of insects as agents of defect was also stressed in "Timber Resources for America's Future." Insects kill more timber than diseases, and the reduction in growth and quality caused by these pests constitutes damage loss greater than that from outright killing. In an earlier publication, Snyder (21) described and classified insect-caused defects in timber according to extent and type of damage. Morris (19) is presently studying the reduction in grade of hardwood lumber due to trunk-boring insects in living trees.

Most of the information available on defect consists of descriptions of types, their identification, and effect upon grade, whether in a tree, log, or board. The handbook by Lockard, Putnam, and Carpenter (18) is the standard reference for description and evaluation of log defects in southern hardwoods. In the Piedmont, however, except in the case of fire, little research has been done to determine prevalence, specific causes, and relative importance of defects in different species under stand conditions, or to formulate control or management practices for minimizing defect.

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[2] Growth impact is defined as the total damage, including mortality and growth loss, due to destructive agents.

It has not been intended that this work will define grading practices or will prescribe final forest management measures for reducing degrade in the future. The purpose of the study is limited to providing basic information on incidence, extent and causes of, or possible influences contributing to defect in the many hardwoods now growing to merchantable size in the Piedmont.

PLAN OF WORK

The formal investigation was preceded by a small-scale exploratory study in nearby forests to observe the more obvious indicators of defect, and to develop survey and measurement techniques. Identification of many of the defects and their indicators was facilitated by reference to the handbook "Log Defects in Southern Hardwoods," by Lockard, Putnam, and Carpenter (18).

As part of the exploratory study, short, small-diameter bolts (3 feet x 9 inches maximum) exhibiting various types of defect or unfamiliar surface characteristics were collected and sectioned. The extent of defect beneath indicators was measured, and photographs were made showing indicators in slabs and associated defect in successive boards (see pages 21 and 22). Also, a number of diseased trees were sectioned in the woods to determine extent of decay beneath cankers and sporophores.

The exploratory work was followed by the major investigation, which was divided into two parts: a woods survey, and a mill study, carried out in that order. Working in the woods first enabled the surveyor to recognize types of disease and cull by association with their identifying sporophores. These and other small surface indicators would be lost or no longer recognizable had the logs been skidded and hauled to the mill. Hay and Wootten (9), for example, experienced difficulty in examining log faces which had been covered with mud during logging. This sequence of procedure also permitted the investigator to see and evaluate all evident defects including those in cull, which normally would be left in the woods either as species not logged or as cull sections.

Original plans for the mill study were to number, examine, and record defects on 16-foot butt lengths of trees to be cut at logging operations, using the same procedure as in the woods survey. The numbered logs were to be followed to the mill for detailed internal examination. Refinement of procedure during the woods survey was regarded to be desirable before undertaking studies at mills. Limited resources available, however, later forced a revision of the mill study plans.

THE WOODS SURVEY

Methods

The first phase of the study, an extensive woods survey of the Piedmont of North and South Carolina and Georgia, provided information on types and prevalence of defect in relation to species, site, and other influences, and in relation to various individual tree characteristics. Line-transect locations, hereinafter referred to as plots, were selected by a modified systematic sampling method. The number of plots selected per state was proportioned to the area of Piedmont plateau within each state. Thus, 33 plots were selected in North Carolina, 21 in South Carolina, and 46 in Georgia (fig. 1). Eleven of the plots in northwest Georgia, although not in the designated Piedmont land type, were similar to those in the Piedmont plots, and are consequently included in this report.

At each plot location, a compass line was started at the first tree selected well within the stand, and so extended as to stay within an area of given site characteristics. The first 10 hardwood trees 8.0 inches (diameter breast high) or larger that were either along the line or had branches extending over the line were measured. The area of plots was not considered important for analysis of the data in this study.

Plot descriptions included the following: state, county, date, plot number, line direction, aspect, basal area, and site description which took in terrain drainage and general forest and soil type. The approximate age of each stand was obtained from an increment boring of a dominant, average-sized tree of the prevalent species.

The following data were recorded for each tree: species, d. b. h., diameter estimate at upper merchantable limit of stem,[3/] last 10-year radial increment, location of defects or defect indicators on next-poorest face of butt log[4/] (drawn to scale on data sheet), cause of defect when evident, dimensions of cull sections that could be determined, sweep or crook measurement for butt log and for full merchantable length, and compass orientation of the four graded faces of the butt log.

[3/] From forest survey rule of thumb: the point at which the diameter of a limb or the sum of the diameters of several limbs equals one third the diameter of the tree at that point; or, the point at which the stem is 4 inches in diameter.

[4/] The next-poorest face of the butt log was determined by examining all four faces and selecting in the manner described for hardwood log grading by the U. S. Forest Products Laboratory (6). The poorest of the three best faces (next-to-poorest of all four faces) of each sample tree was chosen for detailed examination.

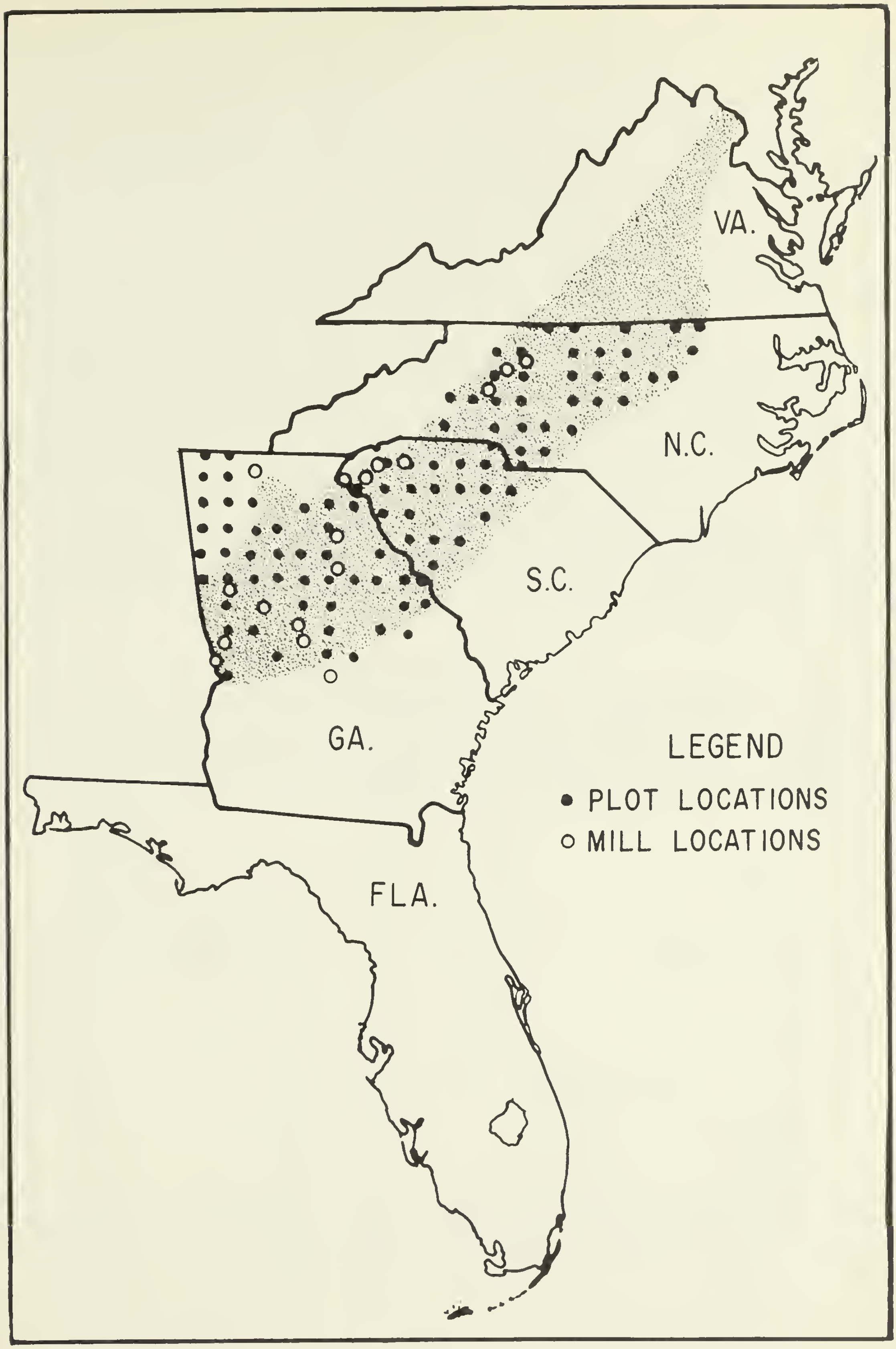

Figure 1.--Location of line-transect plots and mills surveyed. The shaded area represents the Piedmont.

A method of tree quality measurement was sought that would allow rapid assessment of standing trees in the extensive area to be surveyed. It was desired to measure trees so that an estimate could be obtained of the quality of lumber that might be harvested from the sample trees. Thus, the average of the estimates might be interpreted as representative of the general quality of hardwoods in present Piedmont stands. The recording of defects on the next-to-poorest face of the butt log, and the use of the concept of "clear-cuttings" follow Campbell (2, 4) in his tree-grade method of quality measurements. This method, excepting end defects, is based upon factory log grades established by the Forest Products Laboratory (6), and upon the known tendency for the upper logs in a tree to be of lower quality than those next below them. Thus, by grading the butt log of a standing tree, grades of the other logs may be estimated. A recent study of black oaks in southern Illinois has shown that the grade of the best 10-foot section of the butt 16-foot log is a good indicator of the value of the factory grade lumber contained in the whole tree (14). The recording of defects as used in the tree grading method offered a workable field procedure for obtaining the desired information, and for a later analysis and expression of the comparative net effects of different defects upon quality. The small diameters of the majority of the randomly selected sample trees excluded the possibility of using the tree grading system in its strictest sense as a basis of comparison in analyzing the data from the woods survey.

The following is a listing of possible degraders for which trees were examined during this study. It was compiled by borrowing freely from log and surface abnormalities listed by Lockard, Putnam, and Carpenter (18). All types of birdpeck were recorded; for appraising damage, distinction was made between light and heavy attack and whether fresh or occluded, as set forth by Lockard et al. Knots were measured at the knot collar flush with bark surface.

1. Canker
2. Conk
3. Rotten branch
4. Unsound knot
5. Butt rot
6. Heart rot
7. Birdpeck
8. Dormant buds; epicormic, adventitious branches
9. Small knot $1\frac{1}{2}$ inches
10. Medium knot $1\frac{1}{2}$ to 3 inches
11. Large knot 3 inches up
12. Small hole, misc. $\frac{1}{4}$ to $\frac{1}{2}$ inch
13. Medium hole, misc. $\frac{1}{2}$ to 1 inch
14. Large hole, misc. 1 inch up
15. Small hole or scar, insect $\frac{1}{16}$ to $\frac{1}{8}$ inch
16. Medium hole or scar, insect $\frac{1}{8}$ to $\frac{1}{4}$ inch
17. Large hole or scar, insect $\frac{1}{4}$ inch up
18. Burl
19. Butt bulge
20. Stem bulge
21. Bump
22. Bark distortion
23. Butt scar
24. Stem scar
25. Seam
26. Overgrowth
27. Sweep
28. Crook
29. Fork

Definitions of plot and tree characteristics used as bases of measurement are as follows:

Site.--Four general sites were recognized: ridge, slope, cove, and lowland or bottom. On slope sites, survey lines were run at midslope level. The 100 randomly selected plots were distributed in the four classes as follows: ridge 10, slope 47, cove 12, and lowland or bottom 31.

Aspect.--Five variations in aspect were recognized: flat, north, east, south, and west. By aspect, the plot distribution was as follows: flat 28, north 31, east 18, south 10, and west 13.

Basal area.--Basal area was measured with a wedge prism from a point on the plot line where density was estimated as average in the plot and immediate surrounding stand. The observed basal area range was divided into the following four classes: 50 to 90, 100 to 140, 150 to 190, and 200 to 240 square feet per acre.

Species.--Forty different species were encountered on the plots. Since the plots and trees were chosen at random, the number of each species reflects its relative abundance in diameter classes 8.0 inches d. b. h. and larger. White oaks were the most frequently encountered species group (table 1).

Table 1.--Tree species and frequency of occurrence on all plots

Species or species group	Total	Species or species group	Total
	Number		Number
White oaks	274	Sycamore	5
Red oaks	261	Hackberry	3
Sweetgum	127	Redbay	3
Hickories	99	Cottonwood	2
Yellow-poplar	82	White ash	2
Blackgum	53	Black walnut	2
Red maple	28	Holly	1
Elms	26	Silver maple	1
Green ash	12	Sourwood	1
River birch	10	American hornbean	1
Beech	7		

Diameter classes.--The range in diameters was divided into classes to conform to the minimum requirements in the tree-grading system. The percentages in each of the classes were: 8.0 to 9.9 inches, 29 percent; 10.0 to 11.9 inches, 27 percent; 12.0 to 15.9 inches, 31 percent; and 16.0 through 29.0 inches, 13 percent.

Crown classes.--Standard crown class designations were employed: (1) suppressed, (2) intermediate, (3) codominant, and (4) dominant.

Vigor classes.--In this study, vigor is expressed as a measurement of the past 10-year radial increment. Classes are based upon those recognized by Cummings and Zarger (5):

Low--radial increment less than 0.6 inch during past 10 years.
Medium--radial increment 0.6 to 1.3 inches during past 10 years.
High--radial increment 1.4 inches or more during past 10 years.

Sweep and crook.--Measurable sweep in the 16-foot butt logs (greater than 2 inches) and crook cull percentages were calculated from the formulae established by Grosenbaugh (7). Classes of these two cull factors combined were based upon the maximum percentages allowed in the log grades. These were: (1) 0 to 15 percent, (2) 16 to 30 percent, (3) 31 to 50 percent, and (4) 51 percent or higher.

Compass orientation of graded faces.--After the four faces of each butt log had been graded, the general cardinal direction of each was recorded.

The purpose of these observations was to determine whether any correlation exists between defect occurrence on a face and the compass orientation of the face. Plot aspect was also considered in this relationship.

Results

The average diameter of the sampled trees was 12.2 inches (range, 8.0 to 29.0), which gives an indication of lumber quality to be expected. Campbell (3) has stated that tree size is the primary factor in tree grading, and further that a tree must ordinarily be at least 16 inches d. b. h. before it can be considered for either of the upper two grades. Of the trees measured, only 13 percent were 16 inches in diameter or larger.

Most of the trees examined exhibited several types of defect. Figures 2 through 10 illustrate the principal defects and diseases encountered.

Since the sample trees in the woods survey were too small to permit use of tree grades in expressing results from analysis of the data, some other measurement was sought that would show the relative spacing of defects on the bole. Common practice in most hardwood industries limits the minimum length of clear lumber used to 2 feet. This length was therefore arbitrarily chosen as the basis of measurement to express the individual and total effect of defects upon quality. The results were not intended to be representative of actual log grades.

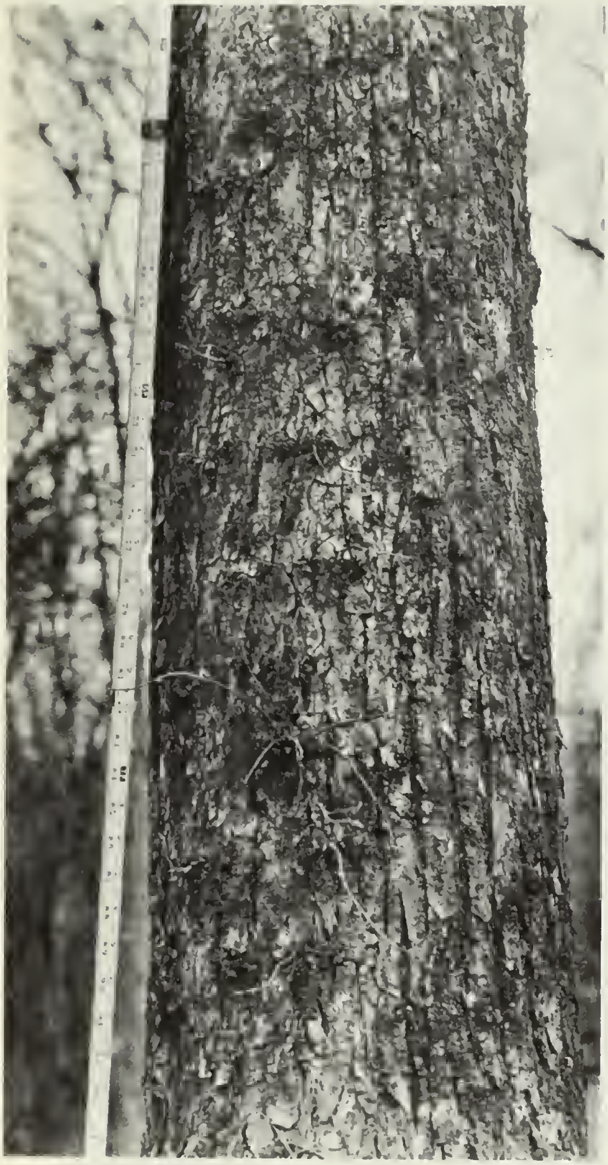

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Figure 2.--Epicormic and adventitious branching in red maple. An example of the severe quality-limiting effect of this common defect.

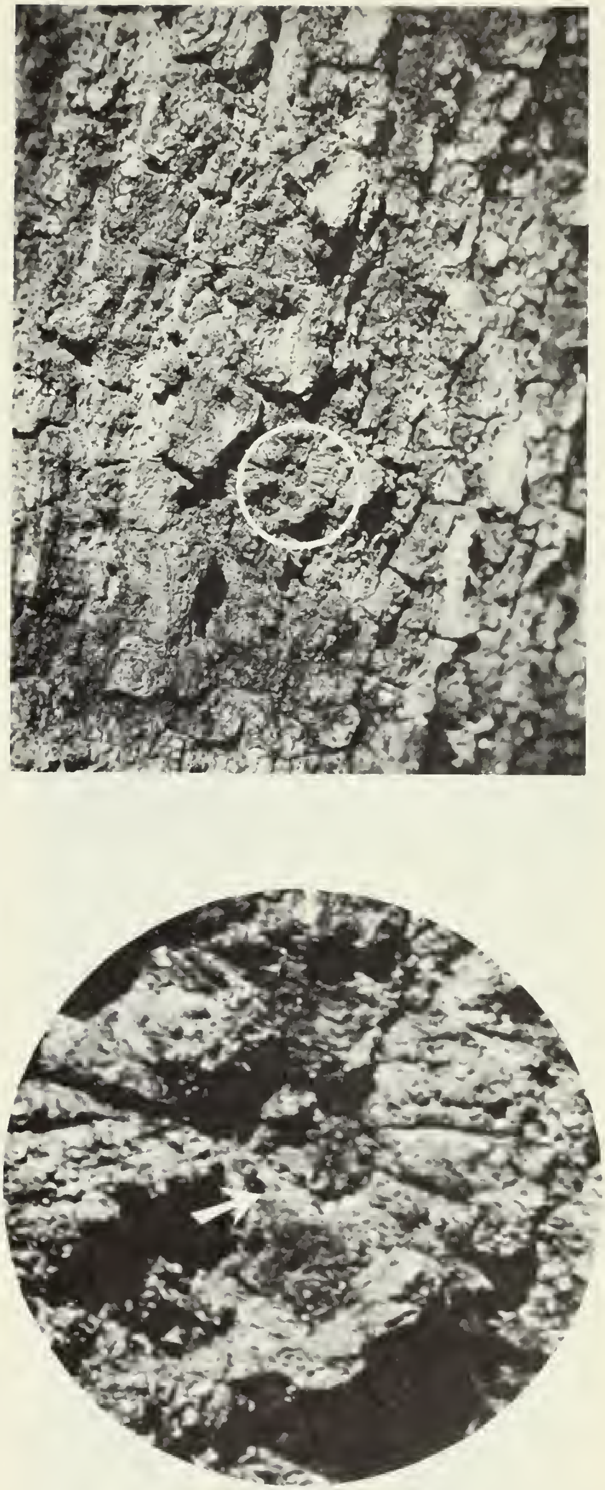

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Figure 3.--Insect borer scar in scarlet oak. Note typical "puckered," swollen appearance of wound tissue in bark.

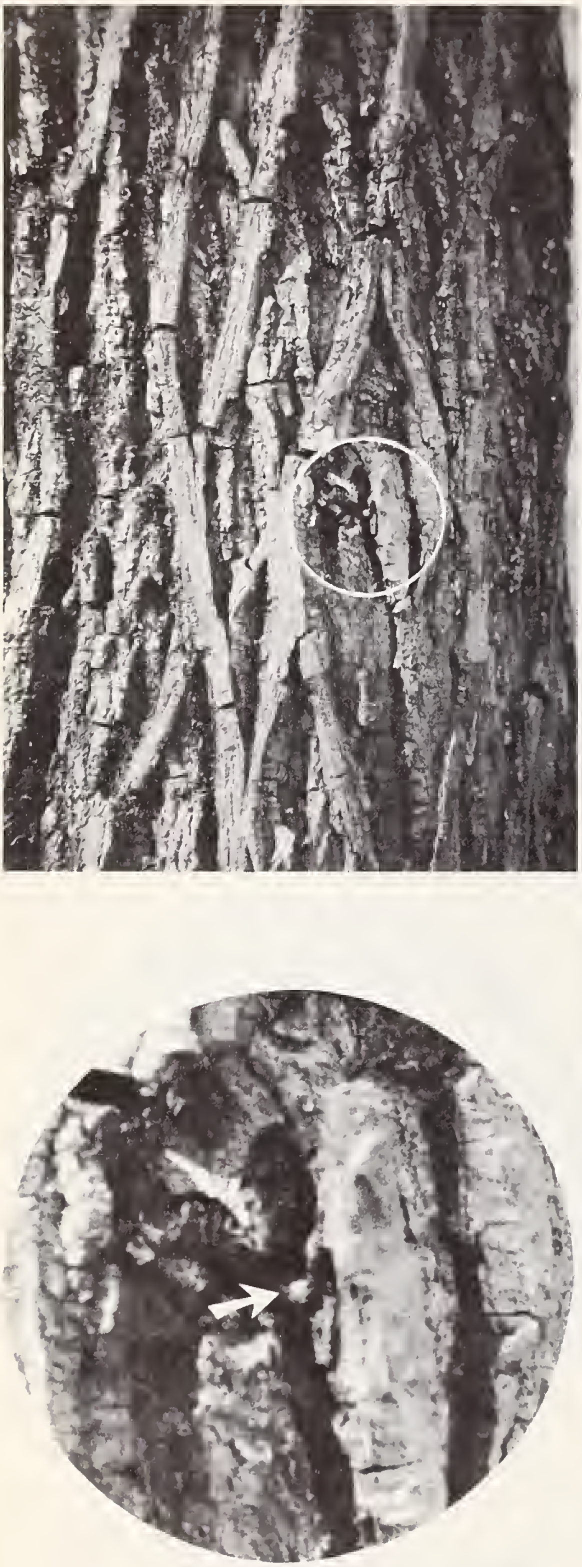

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Figure 4.--Insect entry scar in pignut hickory. "Puckered" callus tissue also evident.

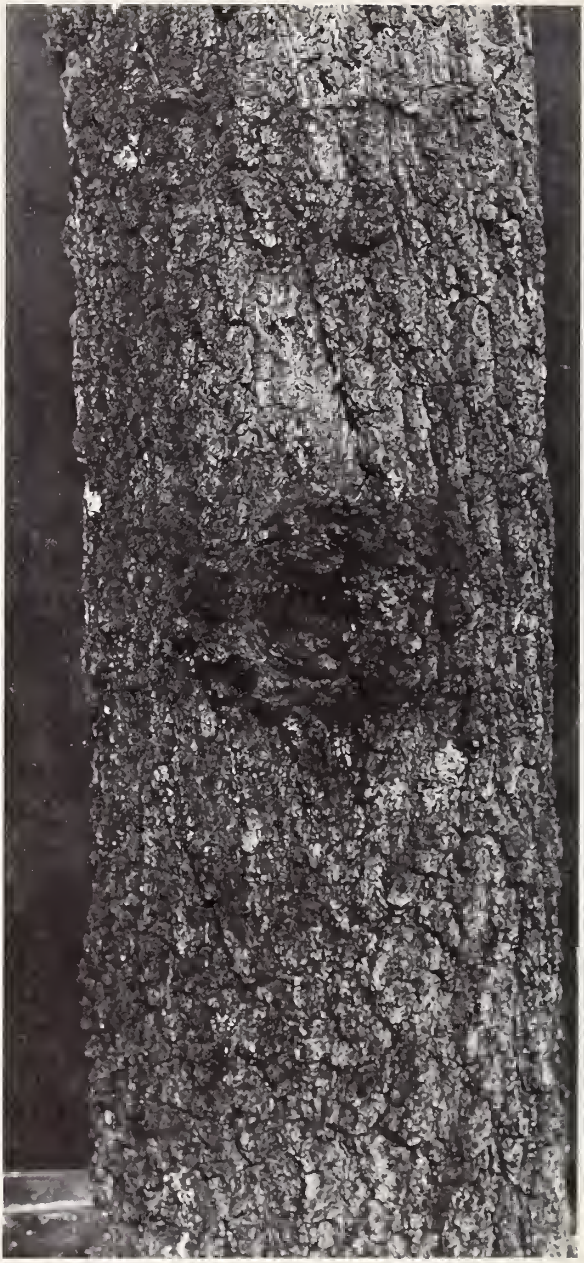

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Figure 5.--*Poria spiculosa* canker on 12-inch southern red oak.

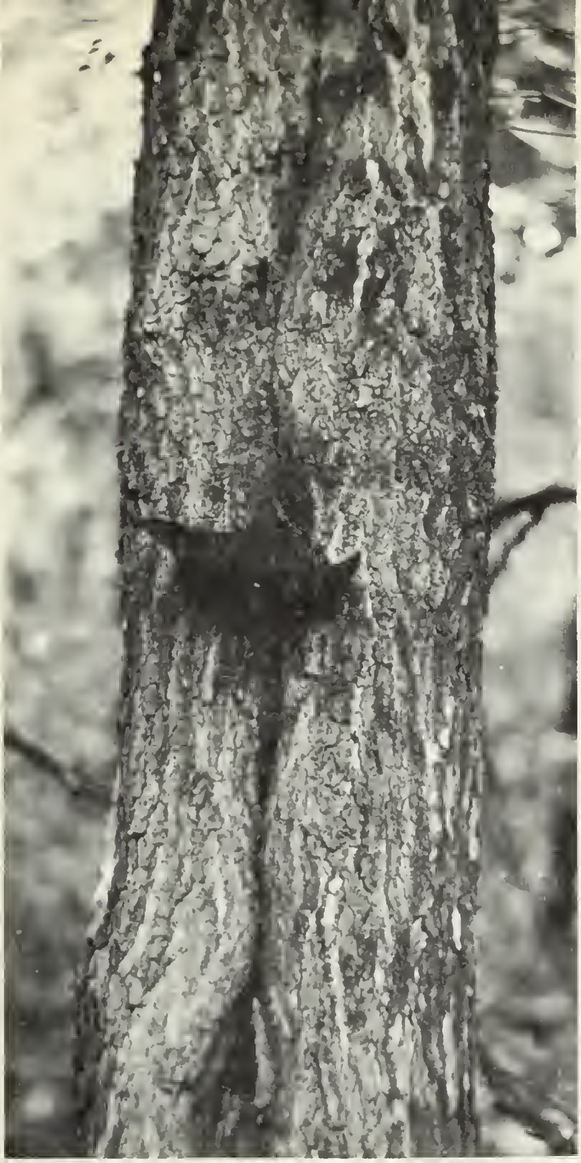

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Figure 6.--Canker and sporophore on 9-inch black oak, produced by Polyporus hispidus.

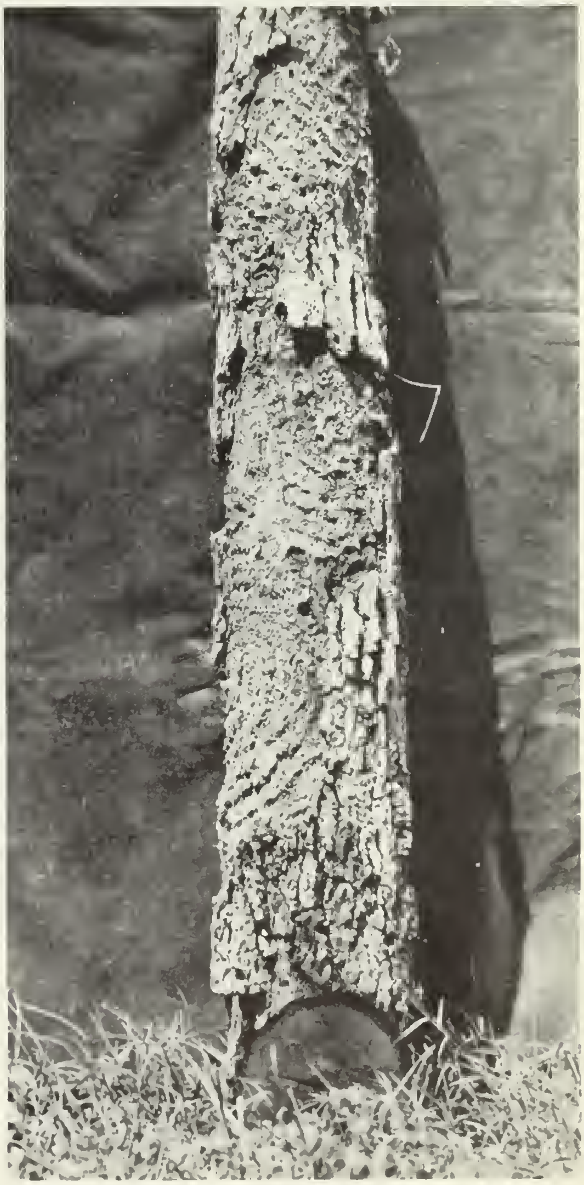

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Figure 7.--Cankered 5-inch post oak. Canker is of the type caused by Endothia parasitica (chestnut-blight fungus).

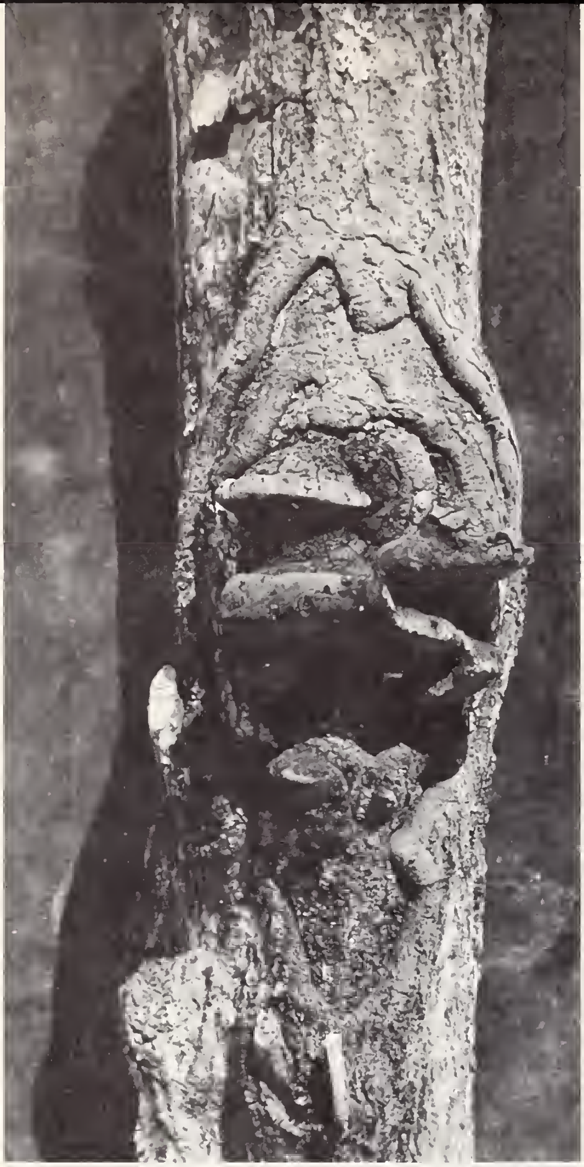

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Figure 8.--Fomes everhartii canker and sporophores on 10-inch water oak.

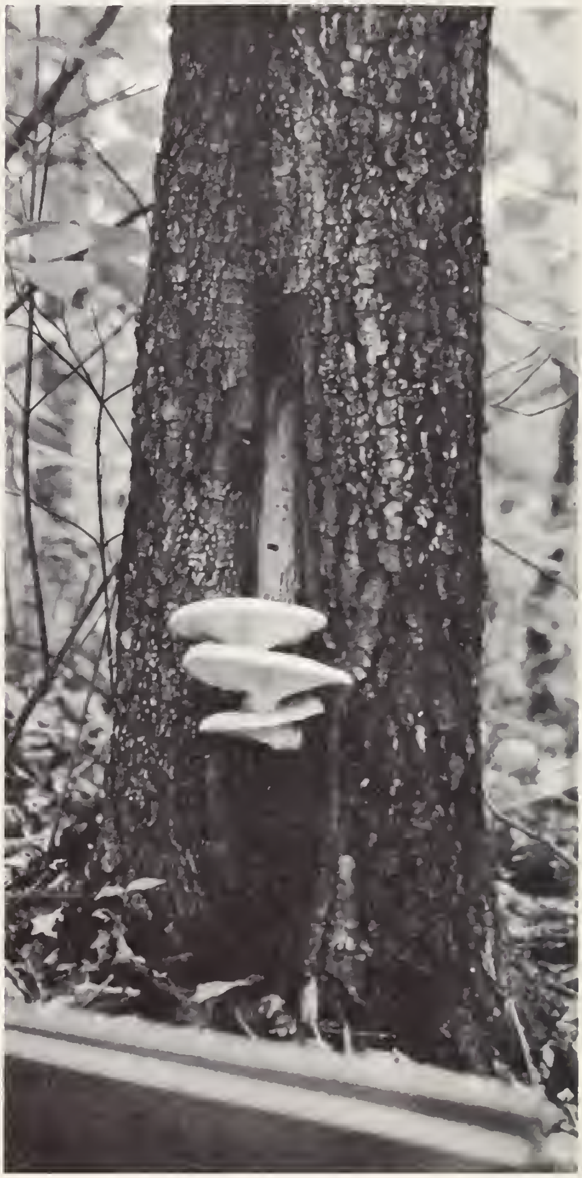

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Figure 9.--Open fire scar on black oak with Pleurotus ostreatus fruiting upon exposed rotted heartwood. Insect borer holes also evident.

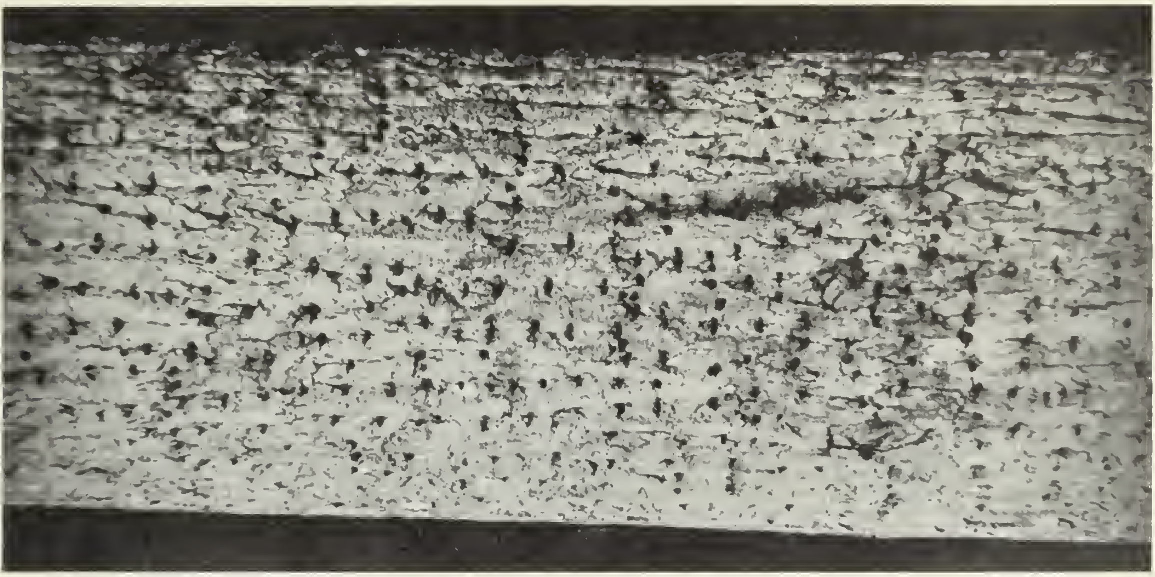

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Figure 10.--Heavy birdpeck defect on 12-inch yellow-poplar.

To obtain the total effect of all defects upon quality, the diagram of each next-to-poorest face was examined and measured for 2-foot lengths or "cuttings" that would be free of defect or "clear" extending from the first board beneath the slab to the heart. The number of clear cuttings was expressed as a percent of total log length. Table 2 shows results from these measurements of 972 trees surveyed, expressed as the actual percent clear in 2-foot cuttings, considering all defects present on the measured face. The extremely small percentage of clear 2-foot cuttings obtainable emphasizes the low quality of present Piedmont hardwoods of the sizes studied.

Table 2.--Quality measurement, by 2-foot cuttings in butt logs of standing trees on next-to-poorest face [1]

Species or species group	Possible 2-foot cuttings	Clear 2-foot cuttings	
	Number	Number	Percent
White oaks	2,192	3	0.14
Red oaks	2,088	4	.19
Sweetgum	1,016	18	1.77
Hickories	792	16	2.02
Yellow-poplar	656	15	2.29
Blackgum	424	0	.00
Red maple	224	5	2.23
Elms	208	15	7.21
Green ash	96	0	.00
River birch	80	0	.00

[1] These data, which are not representative of log grades, show only the relative clearness of the surface of the listed species, on a basis of the entire list of possible degraders listed on page 6. The low percentages shown are mainly the result of the high frequency and scattered spacing of epicormic and adventitious branches on the grading face of the predominantly small-sized trees presently found in the Piedmont.

The cuttings referred to are 2-foot lengths that would be clear or free of all defect. These lengths are the full width of the face.

The same measurement procedure was used to obtain the separate effect of each type of defect. The actual and hypothetical 2-foot clear lengths obtainable were measured between each type of defect. Instead of expressing the results as percent clear, however, the complementary percentages were used to express the effects as percent reduction or loss of clear 2-foot cuttings. The individual effects of the principal quality-limiting defects, other than stem disease and other cull influences, are shown in table 3. In some species the small number of trees measured means, of course, that indications of their defects or quality are questionable. The greatest reduction in clear 2-foot cuttings for all species is shown to be due to small knots. For epicormic and adventitious branching, the least loss occurred in hickories and the greatest in red maples. Insect damage, the second most common defect, was mostly caused by various trunk borers. Approximately three-quarters of the loss from these defects resulted from small and medium-sized insect holes. The oaks exhibited the highest percentage reduction in clear cuttings; yellow-poplar the lowest.

Table 3. --Individual effect of 8 quality-limiting defects in butt logs of standing trees expressed as mean percent reduction in 2-foot clear cuttings on next-to-poorest face 1/

Defects	White oaks	Red oaks	Sweetgum	Hickories	Yellow-poplar	Blackgum	Red maple
				Percent			
Epicormic and adventitious branching 2/	39	51	54	31	59	39	60
Small knots 2/	86	85	73	85	71	88	67
Medium and large knots	16	16	21	17	16	17	16
Small insect holes	12	30	25	12	0	25	37
Medium insect holes	21	28	21	20	19	19	18
Large insect holes	12	20	12	24	12	9	0
Butt and fire scar	16	26	23	15	32	19	25
Stem scar	15	30	29	20	38	19	12

1/ Does not include stem disease, sweep or crook. Measurement of the reduction in clear length due to each type of defect was made independently of any other type present on the face.

2/ The high percentages listed here are again a reflection of the high number and naturally scattered occurrence of these defects on the small-sized trees presently found in the Piedmont. After the trees reach merchantable size and are harvested, many of these indicated defects will be buried beneath some clear wood or lost in the sawn slabs.

Incidence of stem disease is presented in figure 11. The higher percentages of cankers in red oaks and hickories were mainly the result of infection by *Poria spiculosa*.

The principal identified fungi causing cankers and heart rot in red oaks were: *Poria spiculosa*, in 7.7 percent of the trees; *Polyporus hispidus*, 3.4 percent; *Fomes everhartii*, 1.9 percent. Only 0.4 percent of the white oaks were infected by *Polyporus hispidus*. Cankers of the type caused by *Endothia parasitica* were found in 14.3 percent of the post oaks. Of the hickories, 8.1 percent were infected with *Poria spiculosa*. The relative occurrence of *Poria spiculosa* and *Polyporus hispidus* in the species affected is shown in table 4.

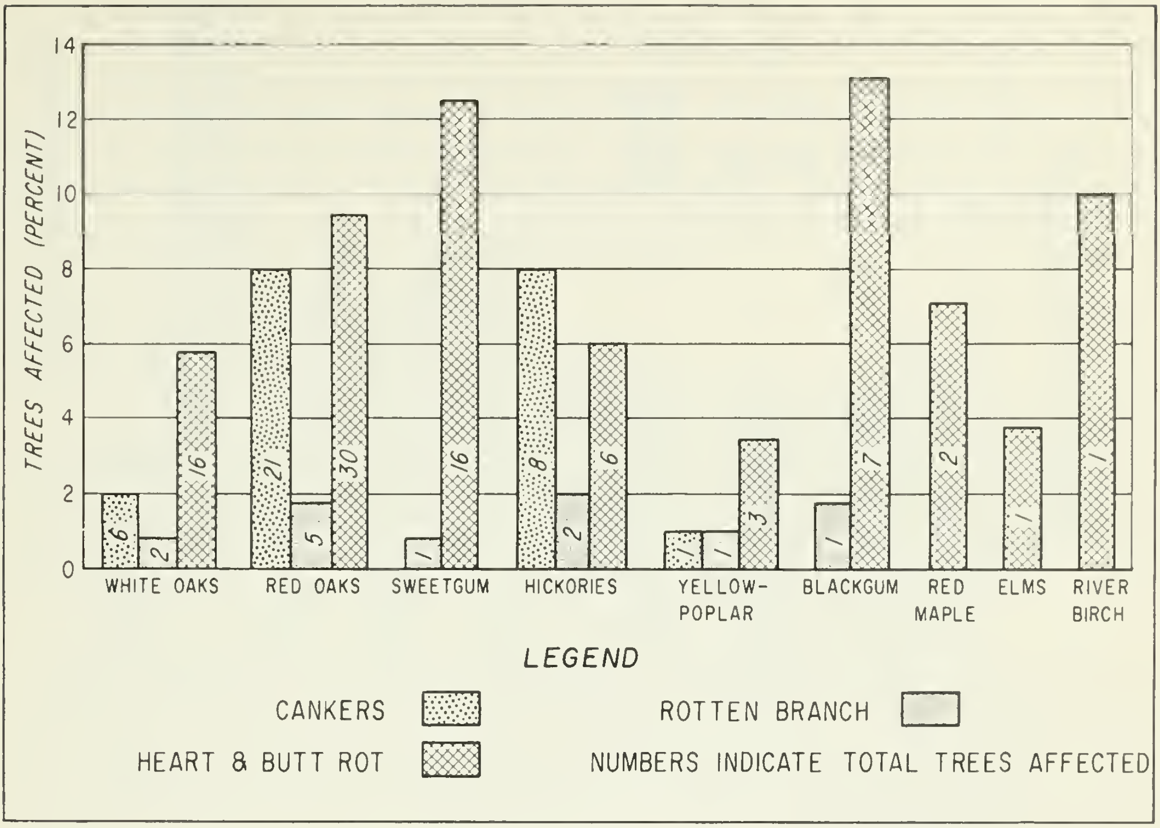

Figure 11.--Incidence of stem disease in butt log by species.

Of 1,000 butt logs measured, 359 had measurable sweep and crook. The average cull percent for butt logs as a result of these 2 defects among 10 species or species groups is illustrated in figure 12. In order of severity, the highest percent sweep or crook was found in green ash, red maple, and blackgum. A further breakdown of the total affected logs into the four classes or intensities of sweep and crook used in tree grading is shown in figure 13. As the intensity of the defect increased, there was a decrease in percent of butt logs affected.

Table 4. --Occurrence of Poria spiculosa and Polyporus hispidus

Fungus	Species affected						
	Water oak	Black oak	Southern red oak	Scarlet oak	White oak	Pignut hickory	Mockernut hickory
	Percentage of trees attacked						
Poria spiculosa	23	7	8	0	0	8	13
Polyporus hispidus	8	3	0	5	0.5	0	0

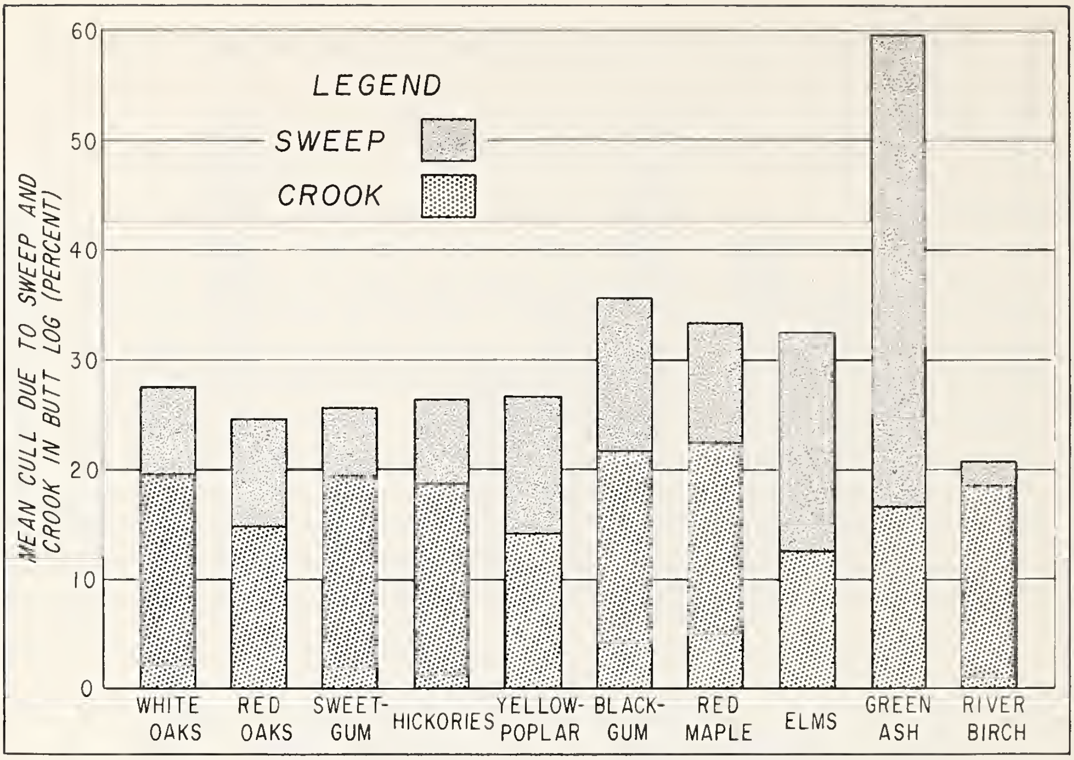

Figure 12.--Average sweep or crook in butt log of 10 major species or species groups. Percentages calculated from formulae established by Grosenbaugh (6).

All types of birdpeck were recorded in order to learn the general incidence and comparative occurrence in the different species. Since affected trees may be re-attacked, the general information, although not accurately measuring degrade, may provide a rough estimate of trees that will be seriously affected in the merchantable crop. Intensity and severity of the damage were recorded for purposes of measuring the degrade caused by the defect. Birdpeck was found in 14 percent of the trees examined. Of the affected trees, 96 percent would not be seriously damaged below the slab, but 4 percent would be degraded because of occluded birdpeck holes. The principal species affected and the percentage of trees showing birdpeck are as follows: Hickories, 44 percent; red maple, 42 percent; elms, 30 percent; white oaks, 14 percent; yellow-poplar, 13 percent; and sweetgum, 8 percent.

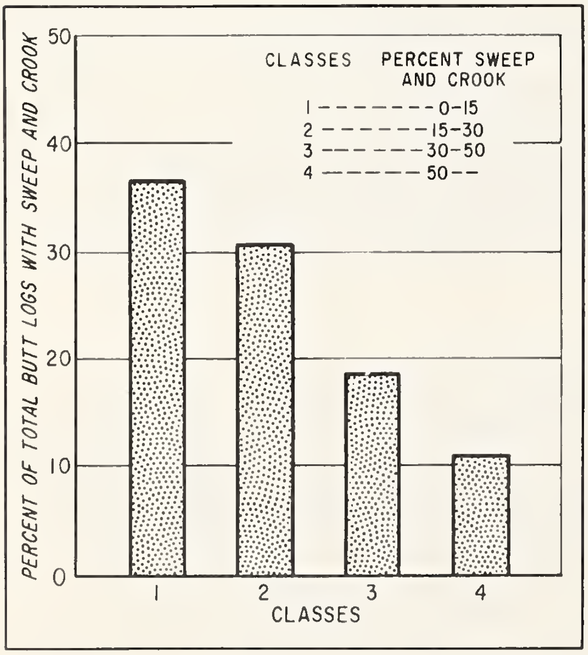

Figure 13.--Distribution of all butt logs affected by sweep or crook.

Fire scars were noted on 12 percent of all plot trees. Practically all fire-scarred trees were located in plots adjacent to a field, the fires apparently having spread into the woods during field burns. A breakdown of fire-scarred trees by state showed Georgia with 17 percent, North Carolina 9 percent, and South Carolina 7 percent. Fire intensity appeared to have been higher in Georgia than in the other states surveyed. Within plots having a fire history in Georgia, 27 percent of the trees were injured; in North Carolina, 19 percent; and in South Carolina, 15 percent.

Defects and Their Correlation with Other Factors

Knottiness.--The prevalence of epicormic and adventitious branching and knots was higher than for any other defect. Their scattered distribution along the bole is the cause of their great effect in decreasing quality. Based upon clear 2-foot cuttings, losses caused by these defects range from 12 to 99 percent, depending upon the tree species and size of knot. It should again be emphasized, however, that many of these defects are lost in slabs.

Intensive measurements were made of the independent influences of site, aspect, diameter class, crown class, vigor, and basal area upon percent loss due to epicormic and adventitious branching. Of these, only diameter, crown class, site, and basal area showed significant effects. These relationships are presented in figure 14. Losses due to epicormic and adventitious branching are highest in stands of high basal area, and in cove and lowland or bottom sites. The results concerning basal area are not correlated with tree size. This is shown by a comparison of the diameter distribution percentages for each basal area class listed in table 5.

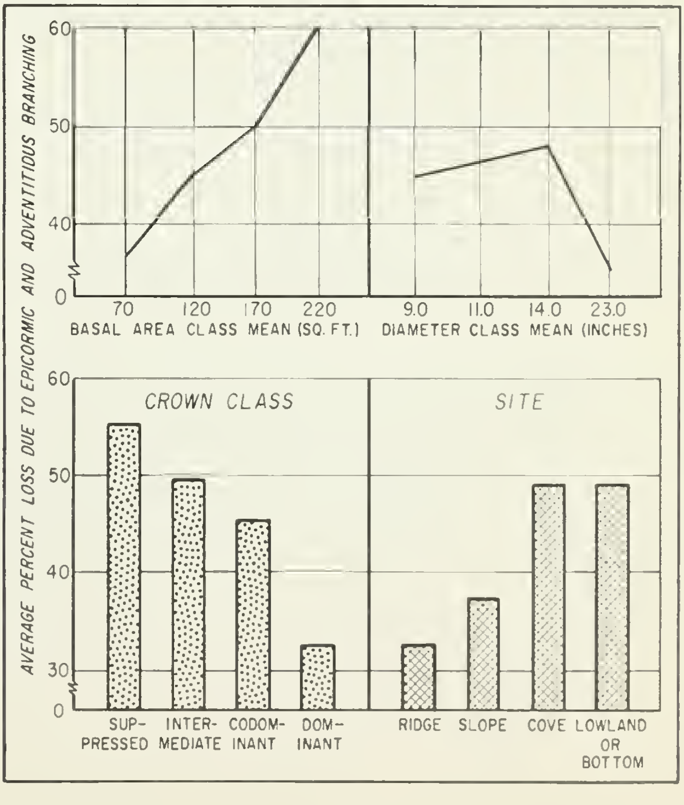

Figure 14.--Correlation between basal area, diameter class, crown class, and site, and loss of 2-foot clear cuttings due to epicormic and adventitious branching.

Table 5. --Distribution of sample tree sizes in the basal area classes

Diameter class mean (inches)	Basal area class			
	50 to 90 square feet	100 to 140 square feet	150 to 190 square feet	200 to 240 square feet
	Percent			
9.0	27.4	31.5	31.9	32.5
11.0	20.9	29.8	26.9	22.5
14.0	41.2	27.2	30.8	30.0
23.0	10.5	11.5	10.4	15.0

The increasing losses due to these branching defects, which are shown in a comparison between the crown classes progressing from dominant through codominant, intermediate and suppressed, suggest a possible relationship between this trend and the phenomenon known as apical dominance. This term is defined as the suppression of lateral bud growth by the terminal bud. Profuse branching along the stem after removal of the terminal is a trait exhibited by trees and many other plants. Thimann and Skoog (22) showed with pea plants that the effect of the terminal bud in inhibiting lateral bud development is due to a growth regulating substance produced in the terminal bud. Quite possibly in a suppressed or crowded tree crown, apical dominance has been lost because of a disturbance of terminal-bud auxin production, and lateral bud development is no longer strongly inhibited.

The lowest losses are in dominant trees or those having a d. b. h. of 16 inches and larger. Similar findings concerning crown development and epicormic branching in white oak have been recently reported by Krajicek (16). The same significant trends were obtained when species, mean diameter, and site were held constant, with basal area varied, and also when species, mean diameter, and basal area were held constant, with site varied.

Insect damage. --Analyses were made of quality loss due to insect defects in relation to each of the diameter, site, basal area, and vigor classes. Of these, site, basal area, and vigor influenced the severity of loss, as shown in figure 15. Losses due to insect defects were lowest in cove sites, in stands of high basal area, and in trees of high vigor. The range in tree diameters in this study was not broad enough to show the relationship reported by Hay and Wootten (9), that quality loss caused by insect damage increases as diameter increases.

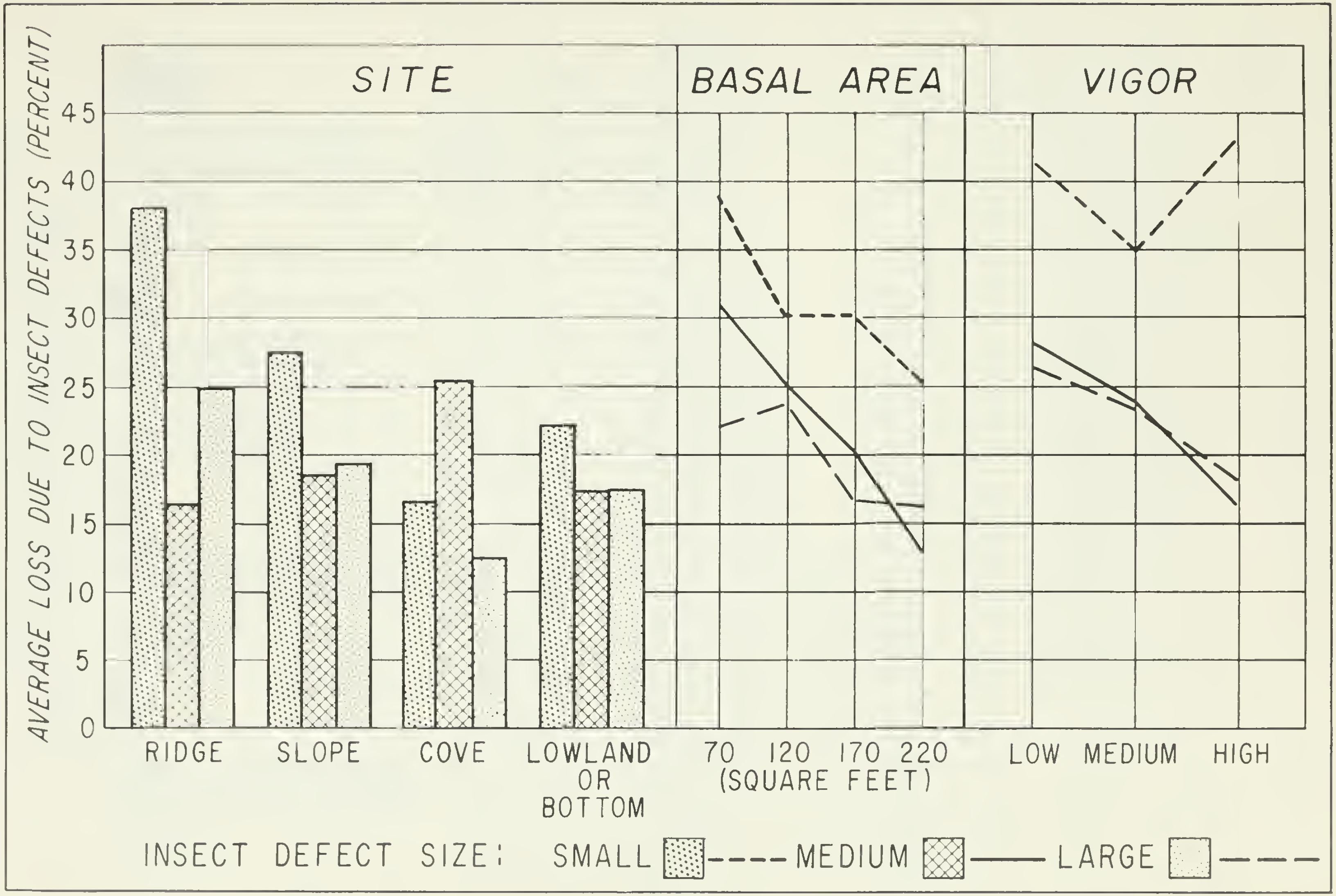

Figure 15.--Loss of 2-foot clear cuttings due to insect defects, by site, basal area, and tree vigor.

Stem disease.--No correlation was found between incidence of stem disease and variable site or other influences.

Influence of Face Direction and Slope Aspect on Face Grade

Analysis of the effects of plot aspect and compass direction of the two poorest faces reveals that for all aspects, 66 percent of the next-to-poorest faces and 67 percent of the poorest faces occurred on either the west or south sides of the trees. Further, the highest percentage (44 percent) of the poorest faces was found on the flats and on the south sides of the trees, while the highest percentage (also 44 percent) of next-to-poorest faces occurred on the south sides of trees growing on west aspects. These data reflect the high prevalence of epicormic and adventitious branching and small knots on the warmer faces.

Examination of losses due to insect defects in relation to compass direction of affected faces showed no significant differences.

Influence of Site upon Tree Vigor

When we examined the relation between vigor of all plot trees and site, we found that medium-vigor trees comprised the majority on ridge, slope, cove, and bottomland sites (fig. 16). There was a greater proportion of low-vigor trees on cove sites than on bottomlands. On the other hand, the percentage of high-vigor trees on bottomlands was more than twice that on cove sites. No relation was found between stand density and vigor-class percentage.

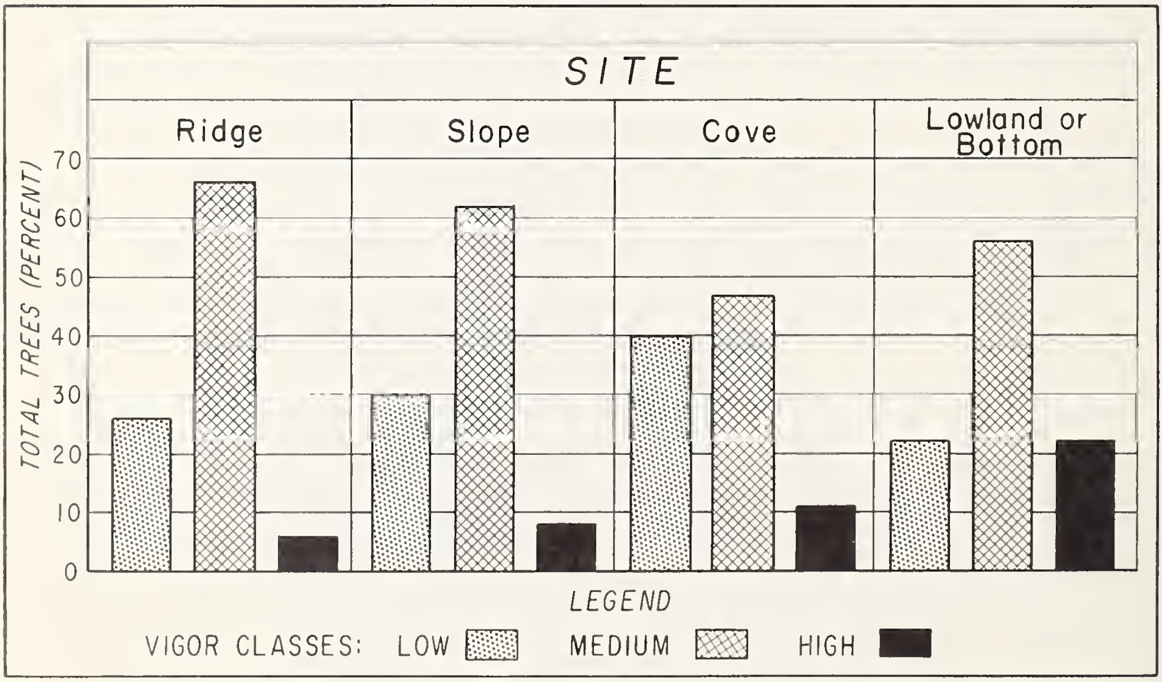

Figure 16.--Distribution of trees in the three vigor classes for each site.

THE MILL STUDY

Methods

As mentioned earlier, a bolter-saw study on small logs revealed some of the relations between external indicators and internal defect (figures 17 through 20). The purpose of the mill study itself was to measure and record defects in the larger merchantable Piedmont hardwoods in relation to visible external indicators. Because of limited resources and difficulties in following numbered logs through the mills within reasonable time, a "hot-log" study was not feasible.

Data were taken at 18 mills cutting Piedmont hardwoods; these mills included small portable mills in the woods and large permanently located installations. Three mills were in North Carolina, four in South Carolina, and eleven in Georgia (fig. 1). It was impossible to make a systematic selection of mills from which to obtain data. Since the market for hardwood lumber was poor during the study, many mills were not logging or sawing hardwoods, or had shut down.

At each mill, 10 hardwood butt logs were examined on the log deck for external characteristics that might be indicative of type and extent of internal defect. The location of defects and other features on each log was plotted to scale on individual forms in the same manner as in the woods survey. Each log was numbered and the measured face marked for ready identification and orientation on the saw carriage. A few of the logs were so sawn that the character and extent of internal defect could neither be accurately measured nor correlated with the charted surface indicators. These logs were discarded as samples. Measurements of possible degrading defects on sawn logs were as follows: blemish character, depth to defect from surface, average length and width of defective or cull portion, and number of boards affected. Board thickness in all species was $1\frac{1}{8}$ inches except in hickory, which was cut into 2-inch boards.

Data were recorded from 160 butt logs of 23 species. The number of logs of some species was inadequate to yield representative data. After consolidating the most-commonly cut species into larger groups, data from a total of 138 logs of five major species or species groups, were analyzed. Each defect was considered as one observation. The reported averages were based upon the total number of all logs of a species.

Results

The averages obtained from the mill study data are listed in table 6. They show that a given defect causes about the same loss regardless of species. All of the features listed were underlain by degrading blemishes in the part of the log where quality lumber should be obtained, and therefore are log defects. The comparatively large volume of cull per butt-rot indicator and other heart-rot indicator is outstanding.

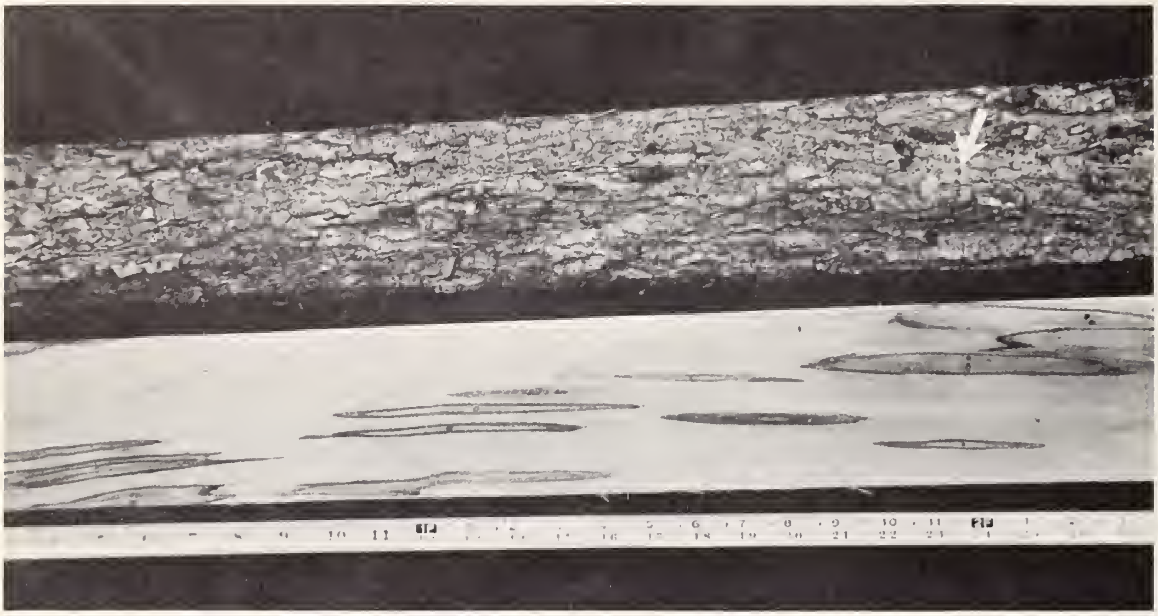

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Figure 17.--Ambrosia beetle defect in red maple. Arrow points to small external indicator of the defect.

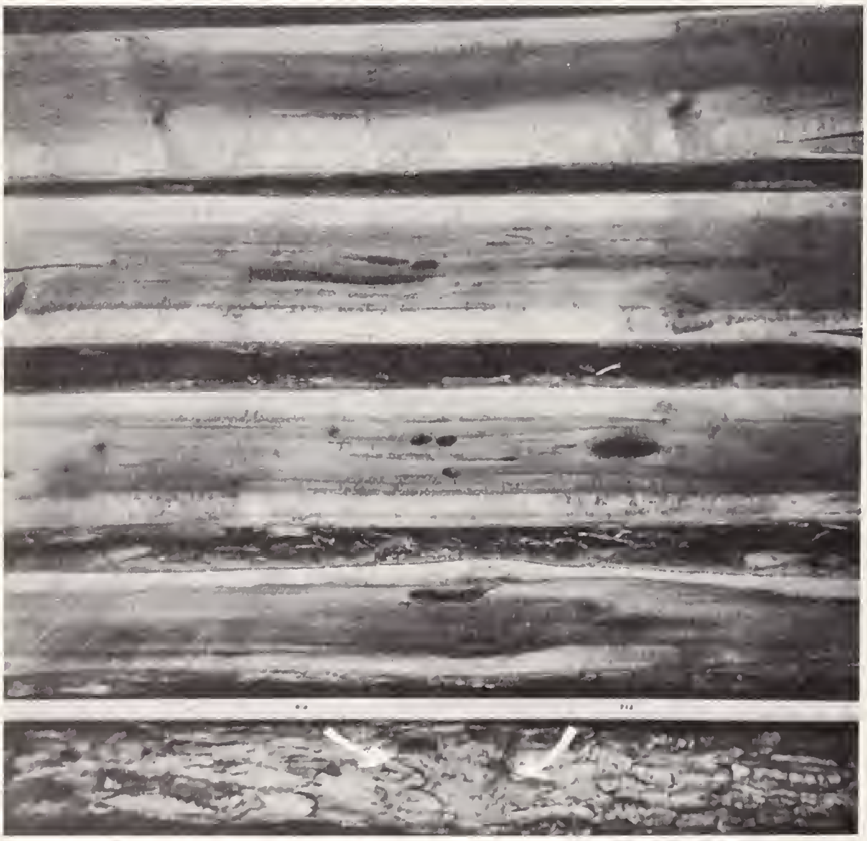

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Figure 18.--Insect grub galleries in 6-inch sweetgum. Large swollen, puckered callus in bark indicates the type of defect.

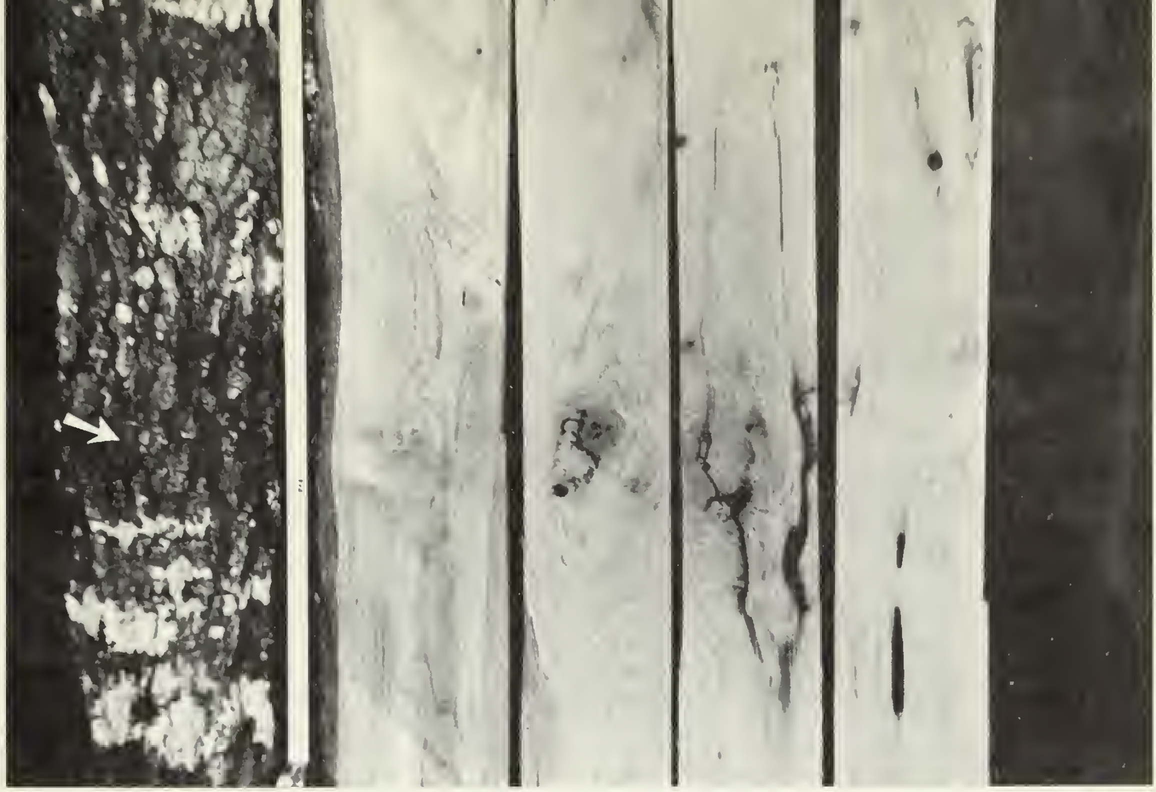

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Figure 19.--Insect borer damage in 12-inch southern red oak. Arrow indicates swollen knot cluster and point of grub entry.

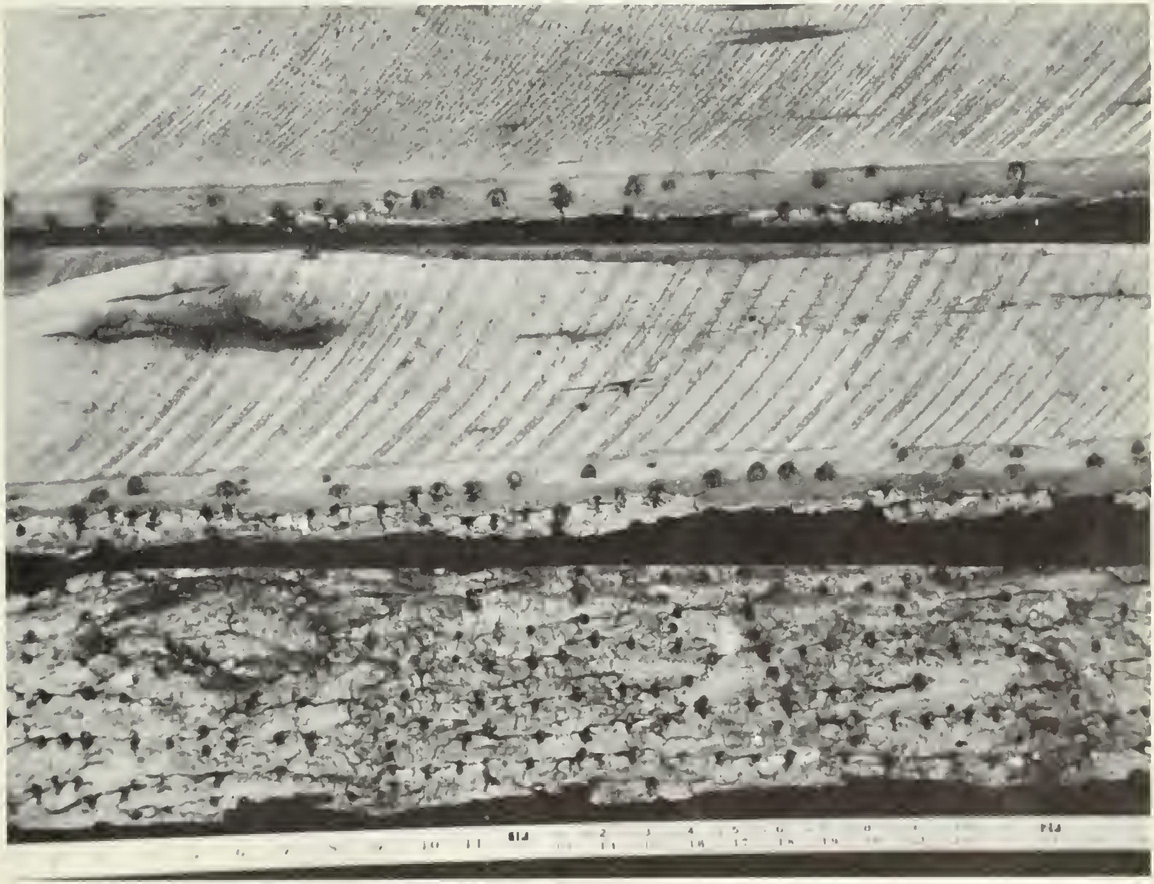

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Figure 20.--Limited internal extent of birdpeck in 12-inch yellow-poplar. Recent wound is indicated by clear line of callus union in bark scar, and shows only in first board.

Table 6. --Mill study measurements of defect extent beneath some common external indicators

D. b. h.		Defect indicator	Defects measured	Depth to defect from surface			Length affected per defect		Area affected per defect		Boards affected	
Range (inches)	Mean (inches)			Minimum	Maximum	Mean	Range	Mean	Range	Mean	Range	Mean
		Type	Number	Inches					Square inches		Number	
RED OAKS, 67 BUTT LOGS MEASURED												
11-40	20.4	Open or healed butt scar or butt bulge	22	1	14	7	4-144	50	16-1296	353	2-15	6
		Medium insect hole, swollen knot scar, or "puckered" scar	129	1	9	4	3-24	9	4-216	38	0-10	3
		Large insect hole, swollen knot scar, or "puckered" scar	41	1	9	4	3-36	14	3-432	77	0-10	3
		Other butt scar	10	1	8	4	12-84	39	63-540	227	0-2	1
		Stem scar	5	1	12	3	12-144	78	72-864	468	0-4	1
WHITE OAKS, 30 BUTT LOGS MEASURED												
11-30	17.4	Open or healed butt scar or butt bulge	8	1	9	5	12-144	46	48-1440	439	2-11	6
		Small insect hole, "puckered" scar, or transverse bark split [1]	1	1	6	4	3-6	5	3-9	5	0-1	1
		Medium insect hole, "puckered" scar, or swollen knot scar	19	1	6	4	3-18	9	4-108	36	0-6	3
		Large insect hole, swollen knot scar, or "puckered" scar	22	1	10	5	4-18	11	12-144	64	0-7	3
		Other butt scar	6	1	4	2	30	30	180	180	0-8	2
		Stem scar	4	1	10	5	6-18	14	36-324	138	0-3	2
SWEETGUM, 20 BUTT LOGS MEASURED												
12-24	16.5	Open or healed butt scar or butt bulge	12	1	7	3	24-108	63	96-864	495	3-8	6
YELLOW-POPLAR, 12 BUTT LOGS MEASURED												
10-32	19.9	Open or healed butt scar or butt bulge	8	3	13	7	12-96	47	48-864	301	3-9	5
		Medium insect hole, swollen knot scar, or "puckered" scar	21	1	5	3	3-12	5	3-48	17	0-4	2
HICKORIES, 9 BUTT LOGS MEASURED												
17-26	21.8	Birdpeck--small pecked-out holes with callus at bottom	[2] 1	1	6	4	6-7	6	6-21	15	0-1	1
		Large insect hole, swollen knot scar, or "puckered" scar	8	3	11	6	3-18	9	5-108	37	1-5	3

[1] Number per 5-square-inch area. Total not counted because of large number.

[2] Averaging one or less per square foot of surface area. Hickory logs with heavy birdpeck defect were not accepted at the mill visited, for lumber from such logs would be useless for the products being manufactured--ski blanks, tool handle stock, picker sticks, and other similar items.

The following example illustrates the practical application of the data in table 6. The scaler examining a 20-inch red oak log with large insect-damage indicators can expect an average of one unaffected board before reaching the defect (fig. 19), each of which will cause an average loss of 14 inches in clear length, and will affect an average of 3 boards inward.

Detection of External Indicators of Defect

Most external indicators of defect are easily detected during quality appraisal before a sale. However, those associated with insect damage are most commonly overlooked or incorrectly identified and may, therefore, be responsible for a large share of erroneous estimates. As an illustration, at one of the portable mills in the lower Piedmont section of Georgia, the operator stated that the logs being cut at his mill during this study were sawing out far below the estimate of the appraiser. The logs measured were oak, averaging 25 inches in diameter $3\frac{1}{2}$ feet above the butt cut. After the logs had been sawn, it was found that excluding knots, 86 percent of the degrading defect noted beneath external indicators was a result of insect attack. The remaining 14 percent resulted from butt and heart rot, beneath readily noticeable butt scars. Obviously, the timber appraiser had not properly evaluated the insect defect indicators present. The usual small size of external signs of insect damage makes them easily overlooked, but their importance in an evaluation of timber cannot be overemphasized.

The internal extent and character of some of the most common and serious defects found beneath their external indicators are illustrated and described in figures 21 through 26.

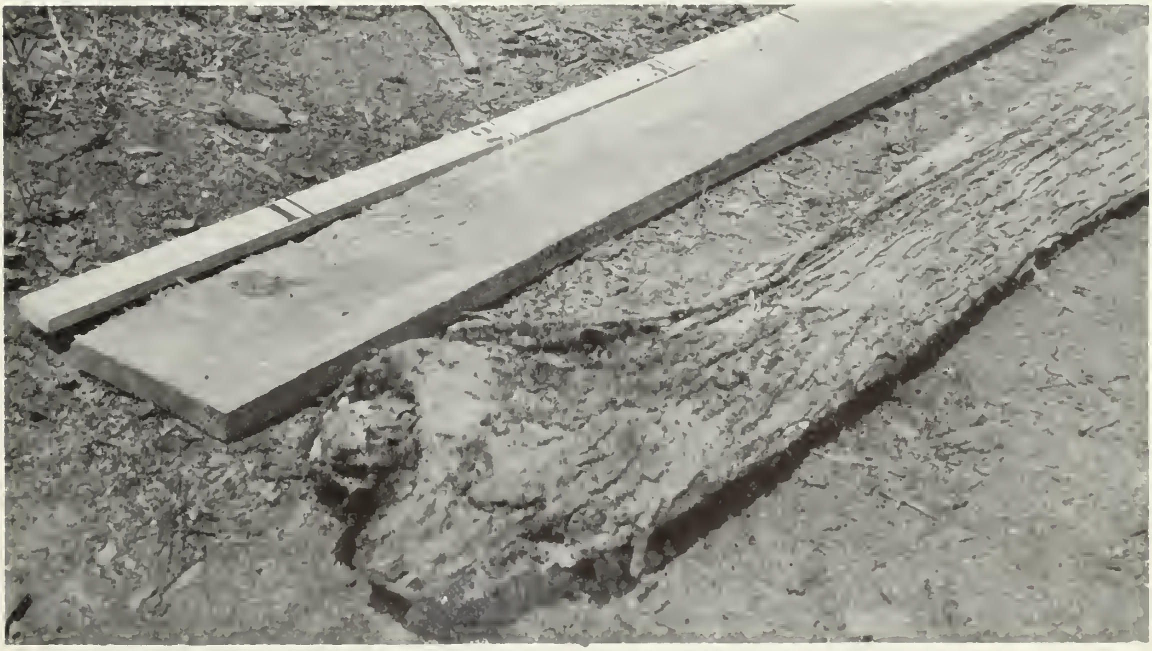

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Figure 21.--Rotten branch stub in 18-inch swamp white oak, with rot in heart board extending 4 feet lengthwise in trunk.

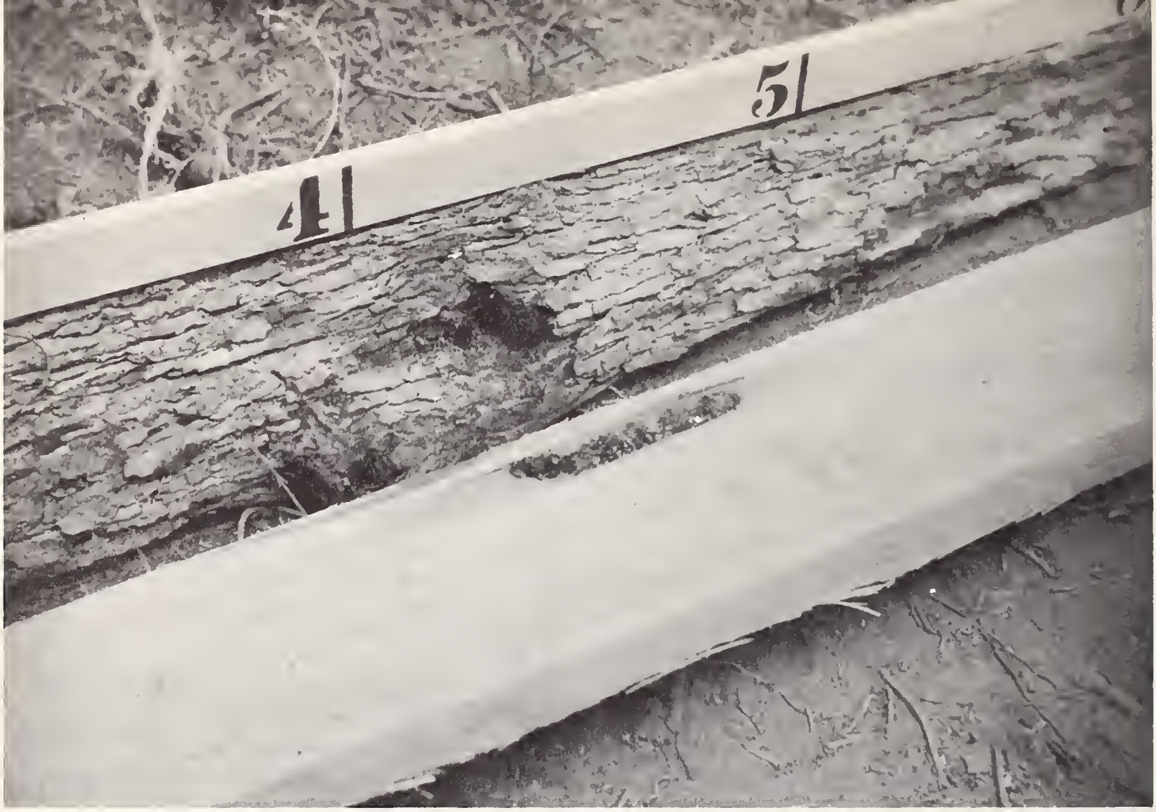

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Figure 22.--Large insect borer damage in 11-inch white oak, showing gallery in second 2-inch board beneath slab.

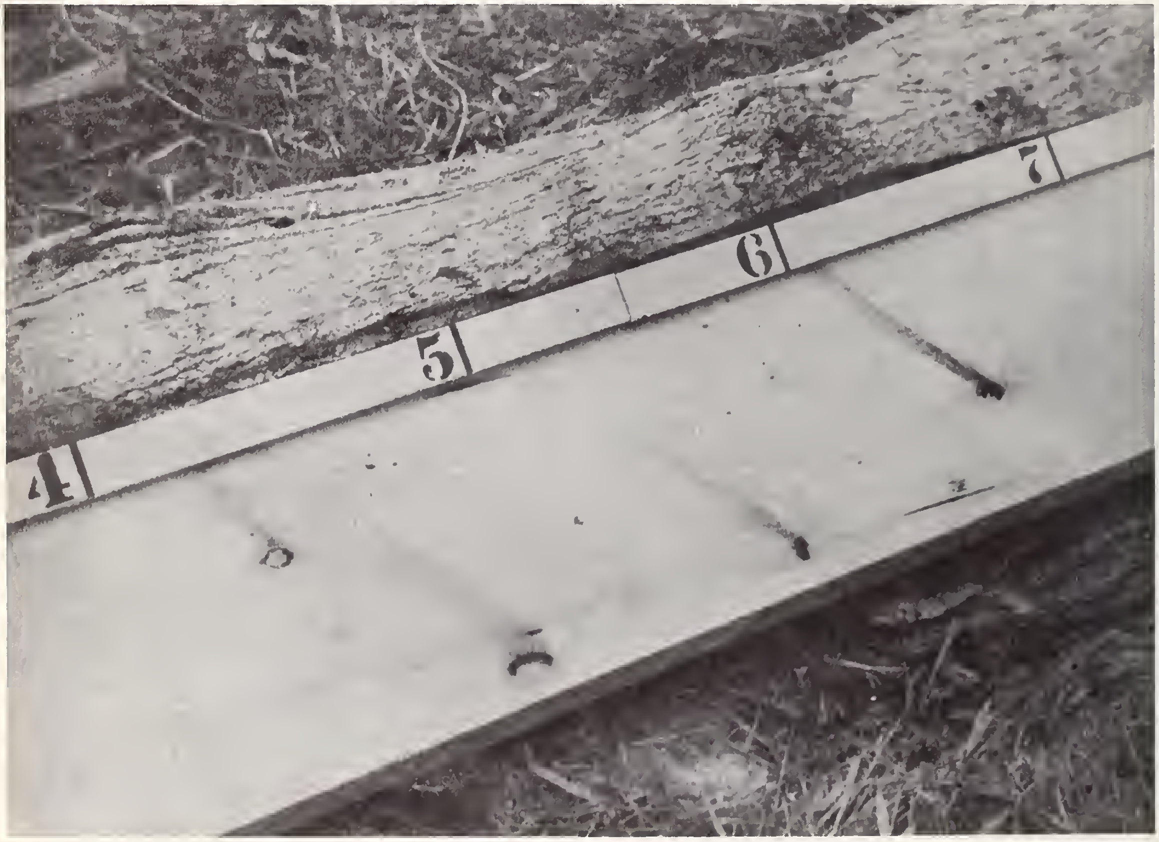

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Figure 23.--Insect borer entry at knot scars in 24-inch redbay. The defects appear in the second 1-inch board beneath the slab.

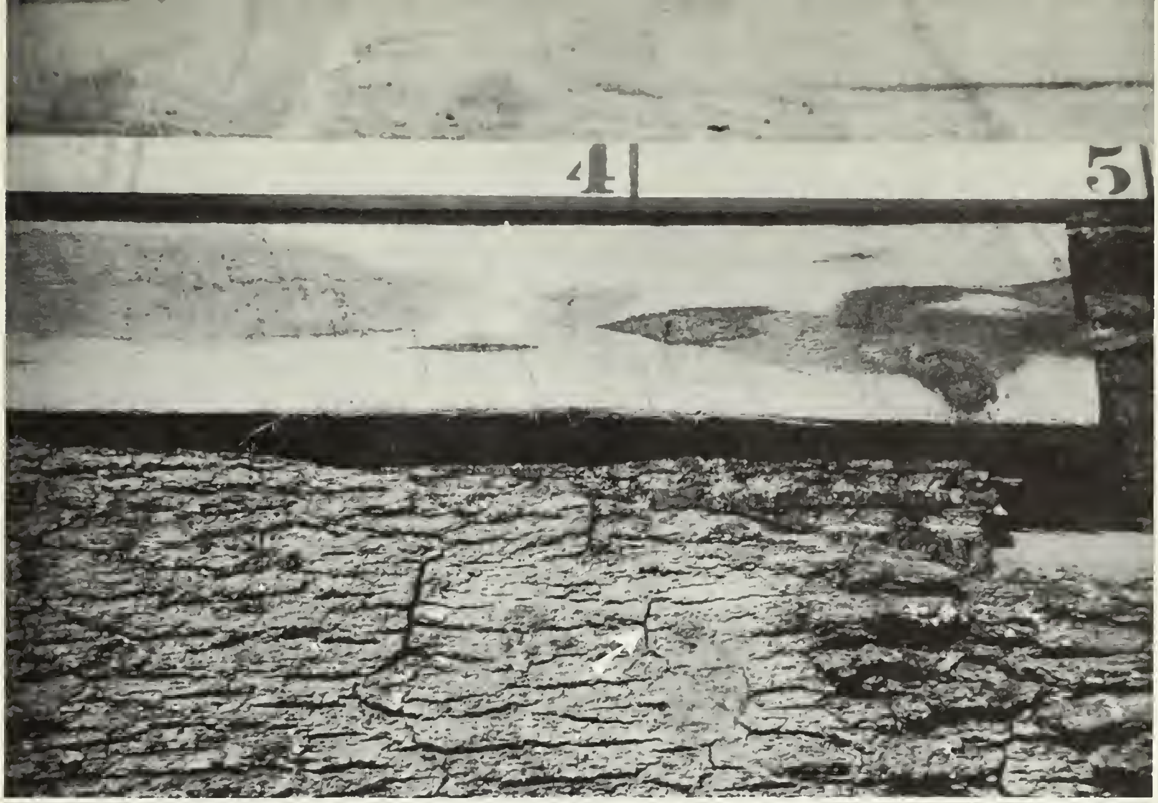

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Figure 24.--Ambrosia beetle defect in 20-inch post oak. Holes and stain illustrated in third 1-inch board. Arrow points to indicators in slab--small swollen transverse bark splits.

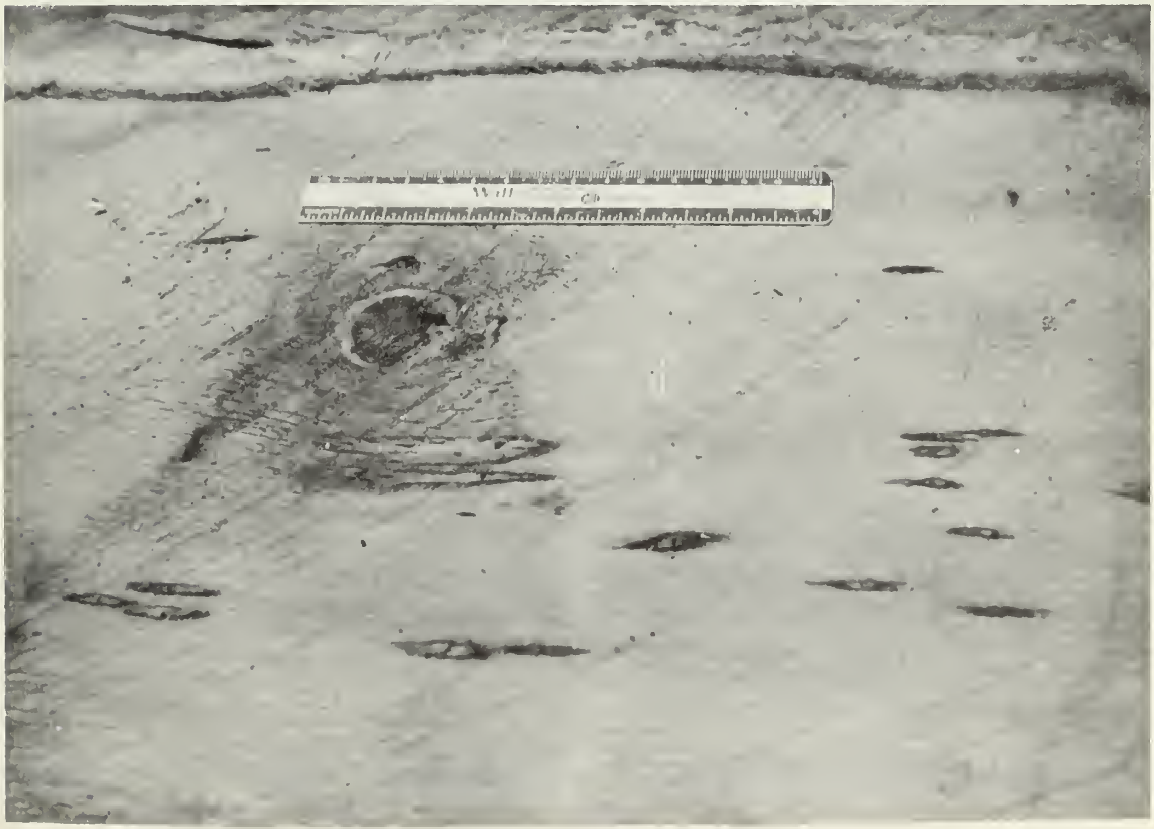

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Figure 25.--Shot-hole borer defect in 30-inch post oak, confined in this log to the slab and outer sapwood. Log face above was flattened, with small swollen transverse bark splits.

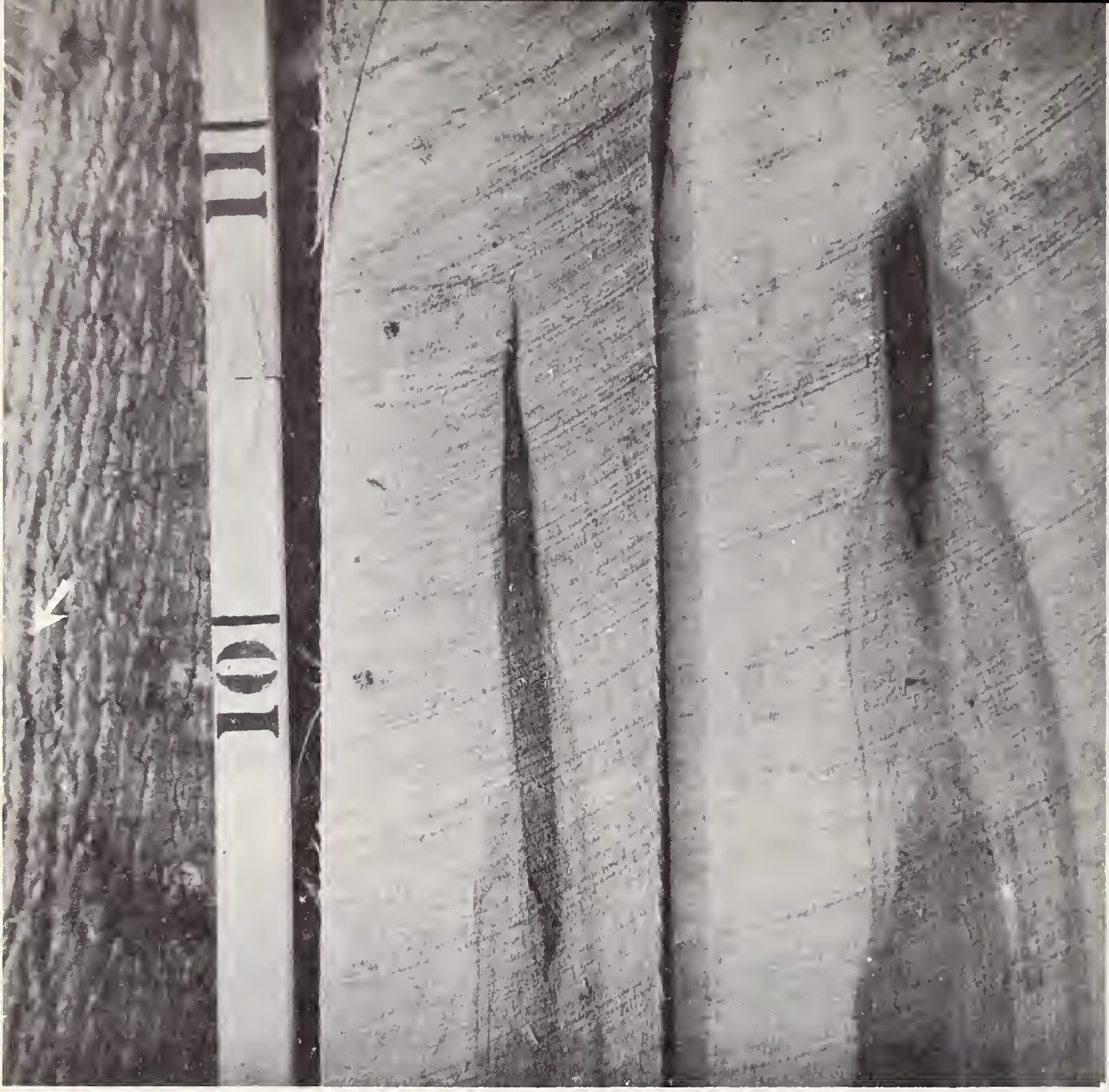

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Figure 26.--Ambrosia beetle defect in 14-inch yellow-poplar, shown in first two 1-inch boards beneath slab. Arrow points to the external indicator, a small hole in a swollen area in the bark.

CONCLUSIONS

Of all of the measured factors that influence present incidence of defect, or have a bearing on the development of defect in Piedmont hardwoods, probably the most important is the small average size of the trees. This is undoubtedly a reflection of their young age rather than low vigor, for approximately 60 percent of the trees studied were of medium vigor, and 11 percent of high vigor. It seems most probable that as the trees increase in size and attain dominance, the incidence of the most prevalent defects, epicormic and adventitious branching and small knots, should decline. This interpretation is obtained from figure 14, which shows that the highest loss from epicormic and adventitious branching is in the 14-inch diameter class, the average diameter class for all trees. A sharp drop in such loss occurred in larger trees. In addition, figure 14 shows that the trees in the dominant crown class have a lower percent loss in clear 2-foot cuttings than those in the other crown classes. Since epicormic and adventitious branching have a tendency to persist up to 16 inches d. b. h., it would seem that a considerable increase in diameter will often be necessary before many trees can be considered satisfactory for production of factory grade lumber.

Although the survey shows that the majority of the trees studied were of low quality, it also shows that the great majority of the trees are relatively sound, as evidenced by the low percentage of trees affected with stem disease. This low percentage of butt cull reflects improved fire protection.

Most of the Piedmont hardwoods today are in second-growth, unmanaged stands. If such stands are protected from fire and overgrazing, and if proper management and harvesting measures are practiced, defects of all types should be substantially reduced.

Good management includes favoring codominant or dominant trees of good form for sawtimber, and eliminating, in intermediate cuts, the large number of trees that today are contributing to the over-all poor quality of Piedmont hardwoods because of their extreme knottiness and high incidence of sweep and crook. Intensive protection of stands from fire and overgrazing would further contribute to better quality by reducing the number of fire scars and other wounds which favor insect and disease attack. The effects of site upon tree vigor are well known and are reaffirmed in figure 16. The relationships illustrated in figure 14 for loss of clear cuttings due to epicormic and adventitious branching, and in figure 15 for losses due to insect defects as influenced by vigor, basal area, and site, may provide bases for further experiments to determine methods for minimizing these defects. Considering the data as a whole, it may be assumed that the more vigorous trees have the least loss of clear cuttings from insect defects. In stands of high basal area there is less loss of clear cuttings from insect defects, but greater loss from epicormic and adventitious branching. A further summary of the data, including all measured influences, shows that the best Piedmont hardwoods are growing in lower slope or cove sites, and with basal areas of 140 to 150 square feet per acre.

Based on results from the mill study, re-emphasis should be placed upon the importance of closely scrutinizing standing timber when doing stand improvement work, as well as when making timber appraisals. Only by this means is it possible to detect the insignificant-appearing insect borer scars that cause a major part of the defect in Piedmont hardwoods.

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